# DSN Research and Technology Support

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*The activities of the Venus Station (DSS 13) and the Microwave Test Facility (MTF) during the period April 19 through June 13, 1976, are discussed and progress noted.*

*Continuing reliability testing and computer program refinement of the remote controlled, unattended automated pulsar observing station is noted, along with routine observations of 17 pulsars. Radar observations of a geostationary satellite are reported, along with the routine automatic testing of the stability of the DSS 13 maser-receiving system. Additional testing of thermal characteristics of semi-flexible coaxial cables is reported, along with phase stabilization measurements thereon.*

*Routine support of the planetary radio astronomy experiment, with 43.25 hours of observations of Jupiter and various radio calibration sources, is reported, along with 18.75 hours of differential VLBI observations in conjunction with Australia, DSS 43.*

*Modifications of the clock synchronization winterization system are reported, along with a discussion of the activities of the DSN High-Power Transmitter Maintenance Facility. A detailed scanning of the orbital region in which geostationary satellites are found is reported as part of the DSN radio frequency interference analysis task.*

The activities of the Development Support Group, in operating the Venus Station (DSS 13) and the Microwave Test Facility (MTF) during the period April 19 through June 13, 1976, are discussed and project support and progress discussed below.

## I. Station Automation

In support of RTOP 70 "Network Monitor, Control, & Operations Technology," DSS 13 will be the demonstration station with which remotely operated, unattended operation is demonstrated.

Including automated tracking, 37.25 hours of station support were provided. Automated tracking, directed from a control computer at JPL, was performed for 23.75 hours, during which data were collected from pulsars 0031−07, 0329+54, 0525+21, 0736−40 and 0823+26. After initial program loading and checkout, no on-site operator intervention was made. The target to be tracked, and other appropriate inputs, were provided from the control computer at JPL to the DSS 13 on-site master computer (an SDS-930 digital computer), and antenna movement, receiver frequency selection, and data collection were performed automatically under the direction of the three onsite computers. These three computers include an SDS-910 for data sampling timing, another SDS-910 for 26-m antenna movement, and the SDS-930 computer for control and data processing. Katherine Moyd, of the Communications Elements Research Section, assisted by station personnel, has been performing this testing.

## II. Pulsar Observations

In support of the radio science experiment "Pulsar Rotation Constancy" NASA Office of Space Sciences (OSS-188-41-51-09), DSS 13 provided 62.75 hours of observations during which the emissions from the pulsars tabulated in Table 1 were recorded. These data, recorded at 2388 MHz, left circular polarization (LCP), are used to determine precise pulse-to-pulse spacing, changes in this spacing, pulse shape, and pulse power content of the signals emitted by these pulsars.

## III. Radar Observations, Satellite

With Goldstone Mars, DSS 14 transmitting and DSS 13 receiving, reflected signal radar observations are being made of a geostationary satellite. Using the DSS 14 64-m antenna and 400-kW S-band transmitter, the satellite is illuminated at a nominal frequency of 2388 MHz. Reception of the reflected signals is accomplished on alternate round-trip light times (RTLT) at DSS 13, using a programmed oscillator controlled receiver and a 26-m antenna. Two stations are necessary because the RTLT is so short (approximately 242 ms) that waveguide switching on a single antenna is impractical. The transmitting station switches frequency approximately 2 MHz every RTLT and the receiving station receives the reflected signal every other RTLT. These observations were conducted for 9 hours.

## IV. Maser-Receiver-NAR Reliability-Stability Testing

Reliability and stability testing of the DSS 13 total receiving system is conducted during nonmanned station periods. The 26-m antenna is prepositioned to a fixed azimuth and elevation, and the Noise-Adding Radiometer (NAR) data collection system automatically records total receiving system temperature as the antenna beam is swept across the sky by the rotation of Earth. During this reporting period, the antenna was positioned at 360 deg azimuth and progressively positioned from 50.7 to 49.9 deg elevation and 450 hours of testing were automatically performed. This testing is done at 2295 MHz, using right circular polarization (RCP) on the 26-m antenna.

## V. Receiver Phase Stability Testing

Continuing with an investigation into the phase stability characteristics of coaxial cables (Ref. 1), temperature rise measurements are being conducted on two cable bundles subjected to solar heating. Two bundles of four each semiflexible coaxial cables, jacketed, were made up and placed on wooden supports atop the cable tray. A thermocouple was inserted underneath the jacketing, in thermal contact with the outer aluminum conductor. One cable bundle was painted white prior to bundling; the other was left in the natural black state. A third thermocouple was used to record ambient air temperature. Care was taken to ensure that no direct solar heating of the thermocouples took place.

It was anticipated that the white cable bundle would experience less solar heating, but quantitative data were desired. During the periods of maximum temperature, the black cable bundle outer conductor temperature rose 7–10°C above ambient air, while the white cable bundle rose only 1–2°C above ambient. Inasmuch as these cable bundles are approximately 1 m long, their thermal time constant is relatively short, and conductor temperature is easily affected by winds. The changes in conductor temperature of the black bundle were much more rapid and more frequent than those in the white bundle, which remained relatively constant, apparently unaffected by winds. Tests will be conducted on much longer samples to learn more about thermal time constants of cable lengths representative of operational conditions in the DSN.

As expected, the white cable bundle performed better thermally than did the black cable bundle. The black cable bundle was then installed into white plastic rectangular conduit, with 8-mm diameter "break out" spaces spaced 19 mm apart. These spaces, on two sides of the conduit, provided free air circulation. While enclosed in white conduit, the black cable bundle stabilized at approximately the same temperature above ambient as did the white jacketed cables, and exhibited approximately the same thermal behavior. Since this type of conduit, trade named "Panduit," has a removable cover, installation into this conduit of coaxial cables that are already installed into cable trays would be relatively easy. Wherever critical phase stability conditions are encountered for cables subjected to solar heating, installation into "Panduit" or similar conduit would limit maximum temperatures and smooth temperature changes, thus minimizing changes in electrical length. Several days of recordings taken during this testing under varying weather conditions (intermittent clouds, over-cast, windy, sunny, etc.) are available, and testing is continuing.

Two proposed techniques for stabilizing coaxial cable electrical lengths are undergoing testing at DSS 13 on 610-m lengths of 12.7-mm diameter, jacketed, Spir-O-Line. Both techniques use approximately 100 MHz as the test frequency and monitor phase changes at that frequency. In one approach, changes in phase are used to modulate internal cable pressurization, using pressures up to 4.2 kg/cm$^2$ as required.

In the other approach, changes in the phase of the test signal are used to introduce compensating phase changes with a phase shifter so as to maintain a constant electrical length.

Although both approaches worked well in laboratory tests on short cable lengths, performance on these 610-m cable lengths under field conditions is poor. Investigation is continuing.

## VI. Microwave Power Transmission

It is planned to test samples of the microwave oven magnetrons produced by three of the major manufacturers. Testing is aimed toward determining the feasibility of using phase locked microwave oven magnetrons as an inexpensive source of microwave power for testing adaptive phased arrays.

## VII. Planetary Radio Astronomy

In support of the radio science experiment "Planetary Radio Astronomy" (OSS 196-41-73-01), DSS 13 measures and records the radiation received, at 2295 MHz, from the planet Jupiter and various radio calibration sources. These measurements are made using the 26-m antenna, the S-band receiving system, and the NAR. During this period, 43.25 hours of observations were made, during which the received radiation from Jupiter and the radio calibration sources tabulated in Table 2 were measured and recorded.

## VIII. Differential VLBI

The advanced Systems experiment "Differential Very Long Baseline Interferometry" (OTDA 310-10-60-56) is designed to develop the capability of navigating interplanetary vehicles relative to "fixed" extragalactic radio objects. Primary to this task is the development of a catalogue of suitable extragalactic objects to be used as guides. In support of this catalogue development, DSS 13, in cooperation with DSS 43, provided 32 hours of support during this period. During these hours, 18.75 hours of actual observing, during which 95 sources were measured, was accomplished. Difficulties at DSS 43 prevented more actual observing from being accomplished.

## IX. Clock Synchronization System

Difficulties at the receiving stations prevented satisfactory reception of some scheduled transmissions, but 10 transmissions, for 9.5 hours, were made, with 5 each being made to Australia DSS 42–43 and Spain DSS 62–63. A X12 multiplier failed in the 100-kW transmitter exciter, but the spare was installed and the system was restored to service.

The winterization system, which prevents the transmitter cooling water system from freezing, was modified during this period to reduce energy consumption. Previously, thermostatic controls turned the pumps on and off as a function of air temperature alone. When the air dropped to the set point temperature of 8°C (47°F), the pumps would come on and remain on until the air temperature rose above the set point temperature plus thermostat hysteresis. Often the air temperature would drop to the set point temperature, and remain there for hours without reaching freezing point, resulting in long term operation of the pumps and resulting heating of the water. The control system modification now turns on the pumps when both the air and water temperature fall to 10°C (50°F). The pumps will remain on until the water is heated to 27°C (80°F) or the air temperature rises to 10°C (50°F) plus thermostat hysteresis, whichever comes first. Restarting of the pumps will then occur only if both air and water temperature again fall to 10°C (50°F).

## X. Deep Space Network High-Power Transmitter Maintenance Facility (DSN HPTMF)

The DSN HPTMF, located at DSS 13 and the MTF, continued to support the 10, 20, and 100-kW transmitters used in the DSN. Special testing of a 450-kW klystron to be loaned to Arecibo Radio Observatory was also accomplished.

At the request of the Cognizant Operations Engineer (COE) and the Cognizant Subsystem Manager (CSM), special priority testing of klystrons was accomplished in preparation for the critical phases of the Viking and Helios missions. Four klystrons, 10-kW, Model 4KM50SI (SNs H4-71, J4-45, K4-19, and L5-10) were tested for use as replacement klystrons as needed. Only two klystrons, SNs K4-19 and L5-10, met specifications, and are available for utilization as necessary. Also, similar testing of a 20-kW klystron, Model 5K70SG, SN IO-15, was accomplished, it met all DSN criteria, and is likewise available for use as needed.

A 100-kW klystron, Model X-3060, SN A6-17R2, returned from DSS 63 as defective, was tested at the Viking Lander frequency of 2112.96 MHz to ascertain whether the previously observed output power instability at the low end of the 2110-2120 MHz band would allow utilization at 2113 MHz if necessary. During a two-hour test period, the RF output power remained at the initial value of 101 kW ±3% without readjustment of any parameters, and it was concluded that, at this single frequency, this klystron is usable as a DSN spare, if necessary.

Klystron Model X-3060, SN A6-17R2, was also used at 2115 MHz to provide high-power (100-kW) testing of harmonic filters designed to reduce the fourth harmonic of the 100-kW S-band transmitters installed within the DSN. Three filters, Model F430FA1, SNs 02, 03, and 04 were tested at 100 kW for periods in excess of three hours each, with no anomalies of any kind. These filters were shipped to the COE for Engineering Change Order (ECO) implementation into DSS 43 and DSS 63, with one filter held as a Network spare.

Arecibo Radio Observatory, which is conducting S-band radar observations of Mars in support of the Viking mission, suffered a 450-kW klystron failure. At the request of the Viking Project Office, two 450-kW klystrons were tested (Model X-3070, SNs K1-01 and D7-55R2), and one (D7-55R2) was chosen for loan to Arecibo. Final testing at 400 kW was accomplished using the magnet in which this klystron would be operated at Arecibo, and with Mr. Tom Dickinson, of Arecibo, as an observer. The tested klystron, along with the Arecibo magnet and special water hoses, was airlifted to Arecibo for use as needed. Klystron K1-01 was reinstalled into the 400-kW transmitter on the DSS 13 26-m antenna.

## XI. DSN Radio Frequency Interference Analysis

In support of this program, the 26-m antenna at DSS 13 was used, along with the station receiver and special detection equipment, to search for interfering signals in the 2290–2300 MHz band. In particular, the band was examined for interference emanating from geostationary satellites.

Scanning in both frequency and antenna position at a rate consistent with a desired detection probability, the zero declination ±1 deg region was searched for interfering signals. During 59.25 hours of observations, no positively identified interfering signals were found. The detection system used had a noise "floor" of −154.7 dBm.

## Reference

1. Jackson, E. B., "DSN Research and Technology Support," in *The Deep Space Network Progress Report 42-33*. Jet Propulsion Laboratory, Pasadena, Calif., June 15, 1976.

Table 1. Pulsars observed at DSS 13, April 19 through June 13, 1976

| | | |
|---|---|---|
| 0031−07 | 0823+26 | 1933+16 |
| 0329+54 | 0833−45 | 2021+51 |
| 0355+54 | 1133+16 | 2045−16 |
| 0525+21 | 1237+25 | 2111+46 |
| 0628−28 | 1911−04 | 2218+47 |
| 0736−40 | 1929+10 | |

Table 2. Radio calibration sources observed at DSS 13, April 19 through June 13, 1976

| | | |
|---|---|---|
| 3C17 | 3C138 | OJ 287 |
| 3C48 | 3C218 | PKS 0237-23 |
| 3C84 | 3C309.1 | PKS 2134-00 |
| 3C123 | 3C418 | VRO 4222 |
| | 3C454.3 | |